PHYSICAL, CHEMICAL, AND BIOLOGICAL MONITORING OF THE SATILLA RIVER

Katy Austin[1] and Keith Gates[2]

AUTHORS: [1]Research Coordinator I, [2]Associate Director, University of Georgia Marine Extension Service, 715 Bay Street, Brunswick, GA 31520.
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Abstract. Water quality has become an increasingly important issue in coastal Georgia. In 1999, the University of Georgia Marine Extension Service initiated a five year water quality investigation of Georgia's five major coastal rivers. Physical, chemical and biological monitoring on the Satilla River began in February 2000. Monitored field parameters included temperature, salinity, dissolved oxygen, pH, chlorophyll a, turbidity, and light attenuation profiles. Surface and bottom water samples were collected for laboratory analysis of biological oxygen demand, MPN total and fecal coliform bacteria, total suspended solids, ATP, total and inorganic carbon, total nitrogen, ammonia nitrogen (NH_3), nitrate/nitrite nitrogen (NO_3^-/NO_2^-) and ortho-phosphate ion (PO_4^{3-}) concentrations. Salinity and dissolved oxygen decreased up river, while chlorophyll a and turbidity increased. Normal pH levels were maintained throughout the sampling period in the Satilla River. Preliminary results show up river increases in bacteria, total suspended solids and ATP. In a few cases, MPN bacteria counts exceeded the accepted level of 100 organisms per 100 mL. The average BOD concentration was 1.32 mg/L. In general, nutrient levels increased up river with surface concentrations often higher than bottom concentrations. The data collected on the Satilla River will be incorporated into a comprehensive and predictive computer model of the river, being developed by Dr. Changsheng Chen of the University of Georgia School of Marine Programs. This model will put scientific information into an easily understood, visual format and will be valuable in educating the public and decision makers about water quality and aid in making sound decisions that will protect water quality.

INTRODUCTION

The University of Georgia Marine Extension Service, in a cooperative effort with the University of Georgia School of Marine Programs, began a five year project in 2000 to investigate water quality in Georgia's five major coastal rivers (Fig. 1). Physical, chemical, and biological parameters have been monitored in the Satilla River since February 2000. Project goals include: (1) investigating the biological quality and productivity of the Satilla River, (2) providing the information to Dr. Changsheng Chen of the University of Georgia School of Marine Programs for incorporation into his coastal Georgia river and estuarine models, (3) evaluating the river's current biological health in terms of anecdotal evidence suggesting declining water quality, (4) integrating the

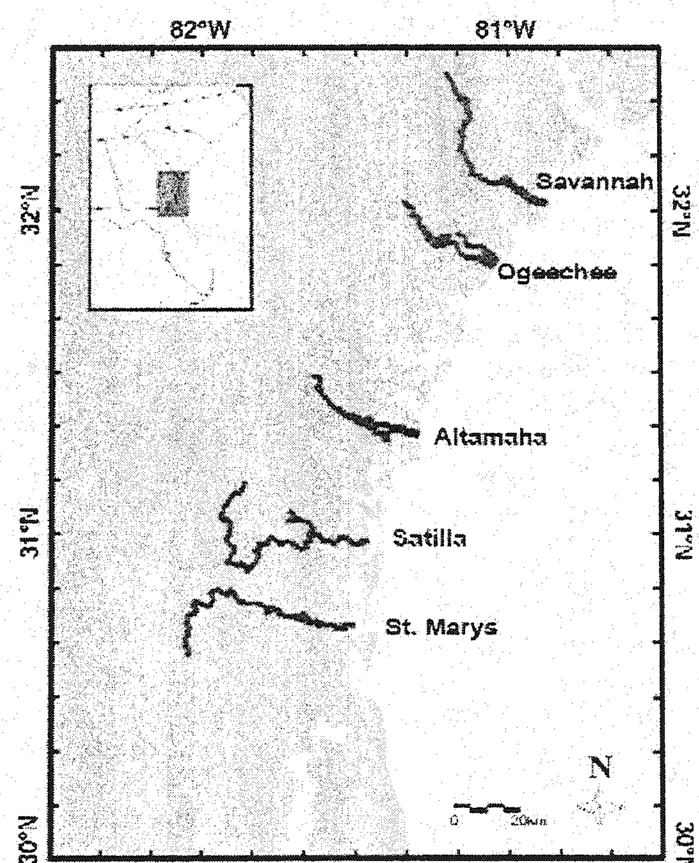

Figure 1. Map of Georgia's five major coastal rivers. Image by Wade Sheldon at the University of Georgia.

results with existing information in a Geographic Information System (GIS) database and analyzing changes in water quality in relation to changes in land use, population growth, and other important identified parameters, and (5) presenting project results and conclusions to interested stakeholders using the latest GIS technology at a coastal and an Atlanta area workshop and through our web site. Preliminary results from water quality data collected at seven monitoring stations on the Satilla River from February 2000 to January 2001 are presented here.

BACKGROUND

Anecdotal evidence suggests that the quality and productivity of coastal rivers and estuaries in Georgia have declined markedly over the last 20 - 30 years. Many longtime coastal residents believe salinity levels are increasing, fishery stocks are declining, and harmful algal populations are growing. However, little complete and easily understood water quality information is available to government planners and other decision makers. Sound scientific decisions about water use and water quality issues have been and continue to be hampered by the lack of a comprehensive database for the rivers and estuaries of coastal Georgia.

Georgia's rapid coastal growth has spawned many concerns about decreased coastal water quality and sparked disputes over the proper use and allocation of coastal resources including the diversion of surface water for commercial, industrial, and residential use. There is anecdotal evidence that the large withdrawals of ground water from the Floridian Aquifer for industry, agriculture, and silviculture have increased estuarine salinities through reduced artesian flow on the surrounding land and through bottom upwelling under the estuaries themselves. Estuaries occur when fresh water from rivers and salt water from the ocean mix. These brackish conditions are vital for crab, shrimp, and certain species of fish during their life cycles. It is important to protect these areas, thus protecting marine life in the estuaries.

Sufficient historical and current scientific data is not available to quantify the perceived changes in coastal salinity or water quality. The only long-term data sets are from the Georgia Department of Natural Resources, the University of Georgia Marine Institute, and the UGA School of Marine Programs' Land Margin Ecosystem Research (LMER) program (Wiegert, 1999). Unfortunately, they date back only to 1980, 1986 and 1995, respectively. Decision makers and the public need understandable scientific evidence to evaluate the impact of coastal growth on water quality, fishery stocks, and estuarine productivity.

METHODS

Seven sample sites were selected on the Satilla River to be monitored once monthly at low tide and once at high tide (fig. 2). Station 1 was positioned near the mouth of the river on Horseshoe Shoal and the remaining stations were distributed up the river. Station 2 was positioned across from Dover Creek. Station 3 was our mid river station. Stations 4 and 5 were located on either side of Bailey's Cut and stations 6 and 7 were placed near Crow Harbor Reach. Stations 1 through 6 were monitored at low tide, while stations 4, 5, and 7 were monitored at high tide to investigate tidal influence on observed parameters. Continuous monitoring devices were placed in shallow areas of stations 1, 3, and 6. In addition to field monitoring, monthly samples were collected using a Niskin bottle for laboratory analyses.

Physical Monitoring

Monitoring on the Satilla River began in February of 2000. Temperature and salinity profiles were measured at the surface and at the bottom of the river across each station using a temperature and salinity meter (YSI 30). Dissolved oxygen profiles were measured using a dissolved oxygen meter (YSI Model 58). The probes were attached to a Niskin bottle using tie wraps, enabling these parameters to be recorded at the exact time and depth of sample collection. Other physical parameters

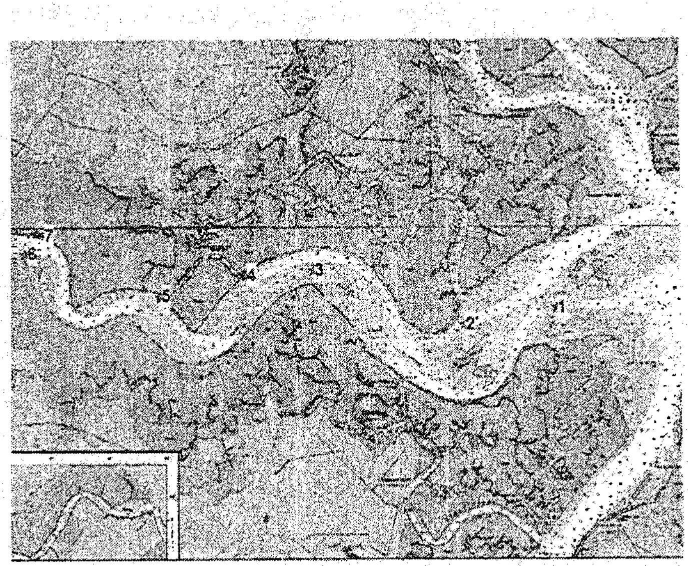

Figure 2. Station map of the Satilla River.

which were monitored monthly include: (1) secchi depth, (2) air temperature and wind speed (Fisher Scientific's hand-held anemometer), (3) pH (Hanna Instruments' pHep 3 pH meter), (4) turbidity (HF Scientific's DRT-15CE Turbidimeter), (5) light attenuation (International Light's IL 1700 Research Radiometer with photodetector) and (6) total suspended solids by filtering a known volume of surface and bottom water through a glass fiber filter, drying to constant weight at 103 - 105°C, and weighing the dried filter (Franson, 1992). A thirteen-hour current study was also conducted on the Satilla River in March of 2000. Each hour, current profiles were measured at two stations using an electromagnetic water current meter (Marsh-McBirney, Incorporated). Salinity, temperature, and dissolved oxygen profiles were also recorded.

Biological Monitoring

Another aspect of this project was to assess the biological quality of the Satilla River. ATP levels were measured using the ATP Luciferin-Luciferase method. The water samples were extracted with tris buffer, mixed with a releasing reagent, and read in a luminometer (Turner Designs) after injecting the luciferin-luciferase into each sample (Franson, 1992; Jago et al., 1989; Turner Designs, 1998b; Turner Designs, 1998c). As an estimate of river productivity, chlorophyll a was measured in the field by means of a field fluorometer (Turner Designs, 10-AU). Samples were also filtered onto glass fiber filters for laboratory analysis of chlorophyll a by the acetone extraction technique, where corrections are made for chlorophyll b and other phaeopigments (Franson, 1992; Turner Designs, 1996; Turner Designs, 1998a). MPN total coliform organisms and MPN *E. coli* organisms were calculated at all sample sites using the multiple fermentation tube American Public Health Association (APHA) technique (Franson, 1992). BOD concentrations were calculated for each station using the Azide modification of the Winkler method (Franson, 1992).

Chemical Monitoring

Nutrient interactions were another factor used in evaluating water quality in the Satilla river estuarine system. Samples were collected at each station in acid-washed polypropylene bottles, and filtered in the laboratory through 0.45 μm pore size polycarbonate filters with a glass fiber pre-filter on top. Filtration was completed on the day of collection using acid-washed glassware. Samples were frozen immediately after filtration. Using Zellweger Analytics' Lachat QuikChem 8000 flow injection analysis system, collected samples have been analyzed for ammonia nitrogen (NH_3), nitrate/nitrite nitrogen (NO_3^-/NO_2^-) and ortho-phosphate ion (PO_4^{3-}) concentrations. Total nitrogen and total and inorganic carbon concentrations have been measured using Euroglass Instruments' TN 3000 and TOC 1200. Through combustion with oxygen, nitrogen and carbon are measured via a photomultiplier tube as NO_2 and CO_2, respectively. Future analysis of total phosphorous and silicates will accompany this information.

Continuous Monitoring

Additional data was collected using both Hydrolab Datasonde 3 Multiprobe Loggers, which recorded temperature, salinity, pH, dissolved oxygen and percent oxygen saturation every thirty minutes, and Sea-Bird Electronics SBE-16 Seacat temperature and salinity recorders, which logged changes in temperature and salinity every ten minutes. In order to safely deploy continuous monitoring equipment, deployment devices were constructed using PVC pipe. Holes were drilled along the length of the pipe and a pulley system was built at the top. This device was mounted several feet deep in the mud where the depth of the water was three feet at low tide. Three anchors were attached to line and stretched from the top of the deployment device out into the river at 120° angles. A Hydrolab Datasonde 3 was deployed in one of these devices at station 6 off and on from May 2000 through October 2000. Deployment devices were placed at stations 1 and 3 in September and Sea-Bird Electronics SBE-16 Seacat temperature and salinity recorders have been used to collect additional data. Presently, Datasonde 3 Multiprobe Loggers are located in the Satilla River at stations 1 and 3.

RESULTS

Preliminary results show several trends in the Satilla River. Average salinity levels show a steady decrease up river with bottom concentrations higher than surface concentrations (fig. 3). Average turbidity and total suspended solids concentrations are higher in bottom samples than surface samples with highest levels recorded at station 6. Levels of ATP generally increase up river. Profiles across each site show a decrease in milligrams per liter of dissolved oxygen corresponding to an increase in temperature. The lowest dissolved oxygen levels were recorded in August and September, averaging 4.03 mg/L, when water temperature reached 30° C. BOD levels remained within a normal range, averaging 1.32

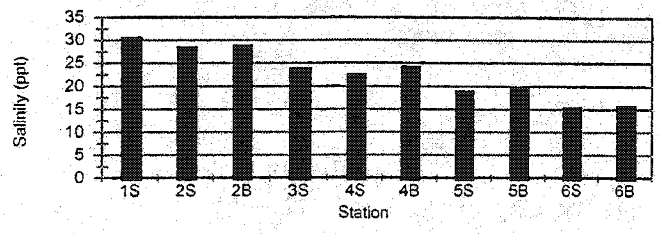

Figure 3. Average salinity levels on the Satilla River, February 2000 to January 2001.

mg/L across all sites. Healthy pH levels, considered 6.5 to 8.5, were commonly recorded in the Satilla River. The range was 6.1 to 8.7 with an average of 7.34. Chlorophyll a concentrations were highest in May and July. The average level of chlorophyll a on the Satilla River was 18 µg/L. Although specific nutrient criteria is not presently available for Georgia, levels in the Satilla River do not seem exceedingly high. NH_3 averaged 0.02 ppm, NO_3^- averaged 0.11 ppm and PO_4^{3-} averaged 0.11 ppm. The average MPN total coliform bacteria count was 72 organisms per 100 mL across all stations from February 2000 to January 2001. The range was <2 organisms per 100 mL to 1600 organisms per 100 mL at station 6 on May 9, 2000. The average MPN *E. coli* count was 17 organisms per 100 mL ranging from <2 to 1600 organisms per 100 mL also at station 6 on May 9, 2000. Average MPN total and fecal coliform bacteria counts recorded were higher up river than at the other stations (fig. 4).

DISCUSSION

One year of monitoring on the Satilla River is complete and the data that was collected during 2000 and part of 2001 will now need to be statistically analyzed. This will allow characterizations to be made concerning the water quality of the Satilla River. Preliminary results reveal generally healthy conditions in the Satilla River. Occasionally high coliform counts were recorded, but sources of contamination are unknown. The data that has been generated from this project will be useful in detecting further change with relation to increases in population and land use. At least one continuous monitoring device will remain in the Satilla River, providing further water quality information.

Presently, data from the Satilla River is being incorporated into Dr. Changsheng Chen's computer model of the river. This model will be able to predict changes in water quality based on scientific information. This valuable tool will enable presentation of water quality information in a visual and animated format.

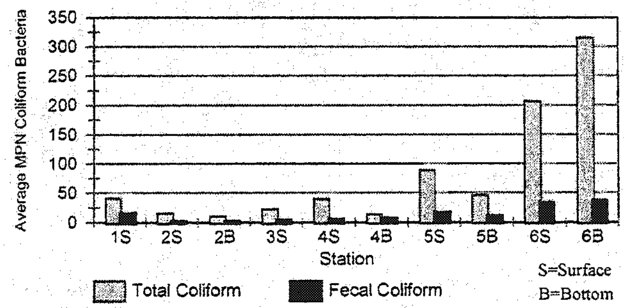

Figure 4. Average MPN Total and Fecal Coliform Bacteria Counts in the Satilla River from February 2000 to January 2001.

Conclusions concerning the Satilla River will be brought to the public and decision makers through workshops in the coastal area and in the Atlanta area and will incorporate Dr. Chen's model, as well as other GIS and graphing techniques.

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